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Efficacy of boron sources on productivity, profitability and energy use efficiency of groundnut (*Arachis hypogaea*) under North East Hill Regions

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ABSTRACT

A field experiment was conducted at ICAR Research Complex for NEH Region, Manipur Centre, Langol Farm, Imphal during 2010-11 to 2011-12 to study the efficacy of boron sources on productivity, profitability and energy use efficiency of groundnut (*Arachis hypogaea* L.) under North East Hill regions. There were 10 treatments comprising various sources of boron. The treatments were replicated thrice in randomized block design. Growth, yield parameters and yield were significantly influenced with the application of various kinds of boron sources as compared to control. Application of boron reduced days to 50% flowering by 4-5 days over control. The 50% days of flowering and number of pods/plant were found linearly (R^2=0.71 and 0.67, respectively) related with dry pod yield of groundnut. However, significantly higher dry pod yield and haulm yield were recorded with solubor (Soil application) (3.5 and 4.72 tonnes/ha), which was 29 and 24% higher than control (2.71 and 3.82 tonnes/ha), respectively. 3% more shelling percent was found in solubor (Soil application) than control. The groundnut productivity (₹ 570.4 ha/day), net returns (₹ 79.8 × 10^3/ha) and B: C ratio (5.45) as well as energy use efficiency (11.3) and energy productivity (0.36 kg/Mj) were recorded maximum with solubor (soil application) followed by borosol (soil application) over no boron application.

Key words: Boron, Coefficient of determination, Economics, Energy use efficiency, Groundnut and yield

The groundnut (*Arachis hypogaea* L.) is one of the major oilseed crops of the country but its production needs to be enhanced to meet the national shortfall as availability of edible oil in India is about 12 kg/head/year against the balanced nutritional requirement of 14.8 kg/head/year (MOF 2009). To meet the vegetable oil requirement of the country at optimum level, we have to increase our production from present level of 29.75 to about 55 million tonnes by 2020 AD to achieve self-reliance in vegetable oil production (Hegde 2009). This crop occupied an area of 6.2 million ha with a production of 7.30 million tonnes and productivity of 1 180 kg/ha (Meena *et al*. 2011). Average productivity in India is very low as compared to USA and China mainly due to mineral deficiencies and rainfed conditions. Boron (B) deficiencies are the important factors responsible for low yield in the cultivars with large seeds (Singh *et al.* 2007). In B-deficient acid soils (below 0.4 ppm available B), low pod filling, shriveled seeds and hollow darkening or off-colour in the center of the seed are commonly observed symptoms causing 10-50% yield losses (Singh *et al*. 2007). For boron fertilization of pulses generally foliar applications at the generative development stages are preferred but little efforts have been made to the study of soil and foliar fertilization of groundnut during the early vegetative stages. Fertilization at early stages could increase yields by different mechanisms compared with fertilization at reproductive stages (Mallariano and Ui-Haq 2000). Application of 0.5-1.0 kg/ha B to the soil normally alleviated the disorder, but there is no recommendation of any agriculture grade B fertilizer in India and farmers depend upon two laboratory grade chemicals (Borax and boric acid), which are not easily available. On the other hand, energy is an essential input to production, transport, and communication process and is thus a driver of economic as well as social development (Kofoworola and Gheewala 2008). Modernization is, in general, tied with increasing inputs of energy in crop production. The energy use efficiency is declining consistently (Mandal *et al.* 2002). Energy input–output relationships vary with the nature and amount of organic manure and chemical fertilizers, plant protection measures, harvesting and threshing operations, yield levels and biomass production (Ghosh *et al*. 2006). To

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increase the production, profitability and energy efficiency, it is essential to grow the recently released large seeded peanut, using latest fertilizer recommendations. Since there are low-cost B products available in the national and international market and are being tested in other crops, it becomes essential to test these new B fertilizers and find out their suitability for soil, seed and foliar application and recommend the most economic and effective sources and methods for peanut. Thus, field experiments were conducted to find out effectiveness and feasibility of commercial grade boron sources, i e Agricol, Chemiebor, Solubor, Borosol and Borax for peanut.

MATERIAL AND METHODS

The field experiments were conducted during *kharif* season at Langol farm of ICAR Research Complex for NEH Region, Manipur Centre, Imphal for the three years, which represents acid soils. During the experimental period of 2010-11 and 2011-12, the rainfall was erratic with an annual precipitation of 1094 mm and 1383 mm. While, the maximum and minimum temperature were 37°C and 18°C, respectively and mean relative humidity varied from 72 to 99% during the crop period. The soil was sandy loam in texture with pH 5.8, organic C 1.56%, available N 185.25 kg/ha, available P 9.2 kg/ha and available K 59 kg/ha. The experiment was laid out in randomized block design with ten treatments of boron (Control, Borax as soil application @ 20 kg/ha, Agricol as soil application @ 20 kg/ha, Chemibor as soil application @ 10 kg/ha, Chemibor-20 as foliar spray @ 6 kg/ha, Solubor as soil application @ 10 kg/ha, Solubor as foliar application @ 5 kg/ha, Borosol as soil application @ 10 kg/ha, Borosol as foliar spray @ 5 kg/ha and Maxibore as soil application @ 10 kg/ha) and replicated thrice. ICGS 76 groundnut cultivar was used for experiment. The groundnut was sown at 45 cm row spacing. Boron as soil application applied at the time of sowing, while in foliar spray done at 30 and 60 days after sowing (DAS). Crops were grown as per recommended package of practices and sown during last fortnight of May every year. Groundnut matured in first fortnight of October. The recommended dose of fertilizer was drilled in bands 8–10 cm below the surface. The dry matter production was determined by uprooting 5 plants randomly from each plot at different days after sowing. The plants were dried in an electric oven at ± 65^0C till the constant dry-weight.

The followings were calculated by using the formula:

Crop profitability (₹/ha/day) = Net returns (₹/ha) ÷ Number of days field occupied (Singh *et al*. 2011), Energy use efficiency = energy output (MJ/ha) ÷ energy input (MJ/ha) (Mandal *et al*. 2002), Net energy = Ouput energy (Mj/ha)÷ Input energy (Mj/ha) (Abdi *et al.* 2012) and Energy productivity = [Grain yield (kg/ha)]/[Input energy (Mj/ha)] (Abdi *et al*. 2012).

RESULTS AND DISCUSSION

Growth and yield attributes

The significant growth attributes and yield attributes were obtained with the application of boron from various sources as compared to control (Table 1). The significantly higher plant height (78.5 cm) and number of branches (11.0/plant) was recorded with the application of Solubor (soil application) over other treatments. Boron starvation greatly reduces the growth and development of groundnut. Hence, applications of boron led to increase in growth and yield attributes during the study. The maximum dry matter accumulation and crop growth rate was recorded at maturity and 30–60 DAS, respectively under all the treatments. Solubor soil application led to 24.3, 39.0 and 40.0% higher dry matter accumulation over control at 30 DAS, 60 DAS and 60-at maturity stage as compared to control. The magnitude of increase being 60.7 and 63.3% number of pegs and matured pods/plant at maturity, respectively. It is well known that B deficiency causes oxidase activity and sugar translocation, carbohydrate metabolism, nucleic acid synthesis in vascular

Table 1 Effect of boron sources on growth and yield attributes of groundnut (mean of two years)

Treatments	Plant height (cm) at maturity	No. of branches/plant	No. of pegs/ plant	Matured pods/plant	Days to 50% flowering	100 kernel weight (g)
Control	66.4	8.8	13.1	9.5	36.7	41.5
Borax (Soil application)	755	11.5	20.1	14.5	32.1	42.5
Agricol (Soil application)	80.4	11.0	17.1	12.5	35.3	41.9
Chemibor (Soil application)	72.4	12.0	20.6	13.1	32.3	42.1
Chemibor-20 (Foliar spray)	67.6	11.3	19.1	11.9	33.5	43.2
Solubor (Soil application)	70.7	14.5	23.0	16.1	32.2	43.4
Solubor (Foliar spray)	78.5	11.0	15.2	11.1	35.5	42.2
Borosol (Soil application)	75.6	12.9	21.1	15.4	32.6	43.1
Borosol (Foliar spray)	76.6	10.4	14.2	13.4	35.1	42.4
Maxibore (Soil application)	72.5	13.4	21.6	14.3	34.3	41.8
SEm ±	0.4	0.2	0.4	0.4	1.1	0.8
CD (*P* =*0.05*)	1.2	0.7	1.2	1.1	3.3	NS

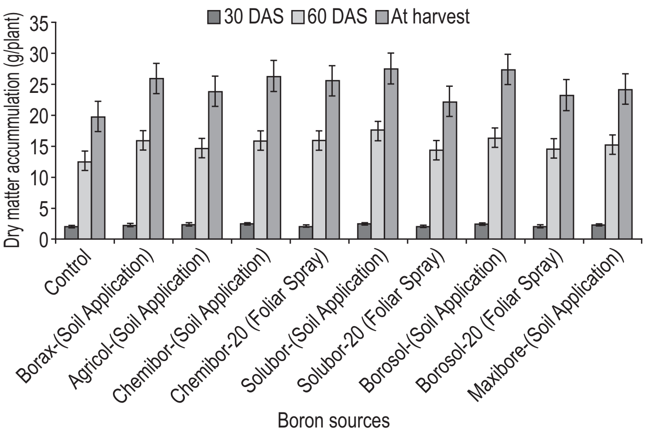

Fig 1 Effect of boron sources on dry matter accumulation of groundnut

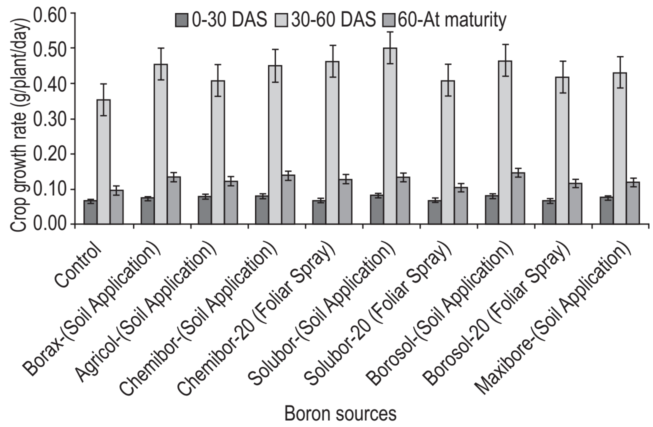

Fig 2 Effect of boron sources on crop growth rate of groundnut Vertical bar represents LSD (P = 0.05)

plants such as root elongation, IAA tube growth (Blevins and Lukaszewski 1998). Boron plays an important role in retaining flowering and fruit setting in pulses (Zhang 2001). However, among the boron sources, solubor as soil application (32.2 DAS) facilitate 5 days early 50% days of flowering than control (36.7 DAS).

Yield and shelling percent

The performance of groundnut was affected under no application of boron when compared with its boron applied plot (Table 2). Branches/plant at maturity, pods/plant and grain weight/pod was adversely affected in control plot. Plot without groundnut application, on an average, produced 70% less pods/plant as compared to solubor (soil application). However, the extent of reduction in grains/pod in control was of lesser magnitude when compared to its boron applied plots. It was observed that increase in yield was due to greater number of filled pods and least number of unfilled pods due to boron application. The cumulative effect of reduction in branches/plant, pods/plant and grains/pod in control treatment led to its lower productivity (2.71 tonnes/ha) when compared to its solubor (soil application) (3.50 tonnes/ha). The positive role of B in quality improvement through its involvement in the synthesis of protein and amino acids further increased the pod yield of groundnut (Chitdeswari and Poongothai 2003). Shelling percent was not significantly affected due to application of boron sources as compared to control. But, on an average 2% higher shelling percent was recorded under solubor (soil application) due to higher pod yield than control.

Economics

The economics of groundnut was varied due to application of boron when compared with its control. Solubor as soil application on an average fetched ₹ 23.61×10^3/ha (42%) more net returns and thus had 1.42 (35%) more B: C ratio than control (Table 2). The higher groundnut productivity coupled with the corresponding haulm yield and with minimal

Table 2 Effect of boron sources on yield, harvest index and shelling percent of groundnut (mean of two years)

Treatments	Dry pod yield (tonnes/ha)	Haulm yield (tonnes/ha)	Biological yield (tonnes/ha)	Harvest index (%)	Shelling percent	Gross return (₹ × 10^3/ha)	Net returns (₹ × 10^3/ha)	B: C ratio
Control	2.7	3.8	6.5	41.5	69.0	70.2	56.3	4.0
Borax (Soil application)	3.1	4.5	7.6	40.8	69.5	84.0	69.3	4.7
Agricol (Soil application)	3.0	4.4	7.3	40.4	69.0	80.2	65.6	4.5
Chemibor (Soil application)	3.2	4.6	7.8	41.0	70.0	86.7	72.0	4.9
Chemibor-20 (Foliar spray)	3.0	4.4	7.4	40.5	70.0	81.3	66.7	4.6
Solubor (Soil application)	3.5	4.7	8.2	42.6	71.0	94.5	79.9	5.5
Solubor (Foliar spray)	3.0	4.2	7.2	41.5	68.5	80.5	65.9	4.5
Borosol (Soil application)	3.4	4.7	8.1	42.1	70.0	91.9	77.3	5.3
Borosol (Foliar spray)	2.9	4.3	7.3	40.3	69.5	79.4	64.6	4.4
Maxibore (Soil application)	3.0	4.4	7.4	40.7	69.0	70.2	56.3	4.0
SEm±	0.1	0.2	0.3	1.5	2.0			
CD (P =0.05)	0.3	0.5	0.8	NS	NS			

Table 3 Effect of boron sources on productivity of groundnut (mean of two years)

Treatments	Groundnut productivity (₹/ha/day)	Energy input (MJ) (× 10^3/ha)	Energy output (MJ) (× 10^3/ha)	Net energy (× 10^3/ha)	Energy use efficiency	Energy productivity (kg/Mj)
Control	401.8	8.4	86.1	77.7	10.3	0.32
Borax (Soil application)	494.8	10.8	100.5	89.7	9.3	0.29
Agricol (Soil application)	468.3	10.8	97.8	87	9.1	0.28
Chemibor (Soil application)	514.4	9.6	103.2	93.6	10.8	0.33
Chemibor-20 (Foliar spray)	476.2	9.2	97.8	88.6	10.6	0.33
Solubor (Soil application)	570.4	9.6	108.9	99.3	11.3	0.36
Solubor (Foliar spray)	470.8	9.0	95.4	86.4	10.6	0.33
Borosol (Soil application)	552.2	9.6	107.4	97.8	11.2	0.35
Borosol (Foliar spray)	461.7	9.0	95.1	86.1	10.6	0.32
Maxibore (Soil application)	401.8	8.4	97.8	89.4	11.6	0.36

increases in cost of cultivation has resulted in higher net returns and B: C ratio in solubor as soil application treatment. Solubor (soil application) increased mean groundnut productivity by 42% over no application of boron. Similar results were reported by (Chitdeswari and Poongothai 2003).

Energy use efficiency

Energy used in groundnut cultivation under different boron sources was computed to find out the energy use efficiency (Table 3). The energy input differed due to use of different kinds of boron sources at different rates. The output energy, however, is dependent on grain as well as haulms yield under different treatments and higher yield registered greater output energy. Application of solubor (as soil application) @ 10 kg/ha gave the maximum energy use efficiency (16.3) followed by borosol (soil application) @ 10 kg/ha (16.0) and least in agricol (soil application) @ 20 kg/ha (12.5) (Table 3). The maximum energy productivity (0.36 kg/Mj) was also recorded under same treatment. Higher energy efficiency might be caused by higher production of output energy due to higher crop yields and lower input energy use in comparison to other boron sources. These results are in close agreement with those of Ghosh *et al.* (2006), Singh *et al.* (2011) and Abdi *et al*. (2012).

Coefficient of determination

A significant correlation between days to 50% flowering and number of pods/plant with grain yield further justified the beneficial effect of boron sources. Days to 50% flowering and number of pods/plant of groundnut was linearly related to dry pod yield with 0.71 and 0.68 coefficient of determination, respectively. It showed that with the decrease

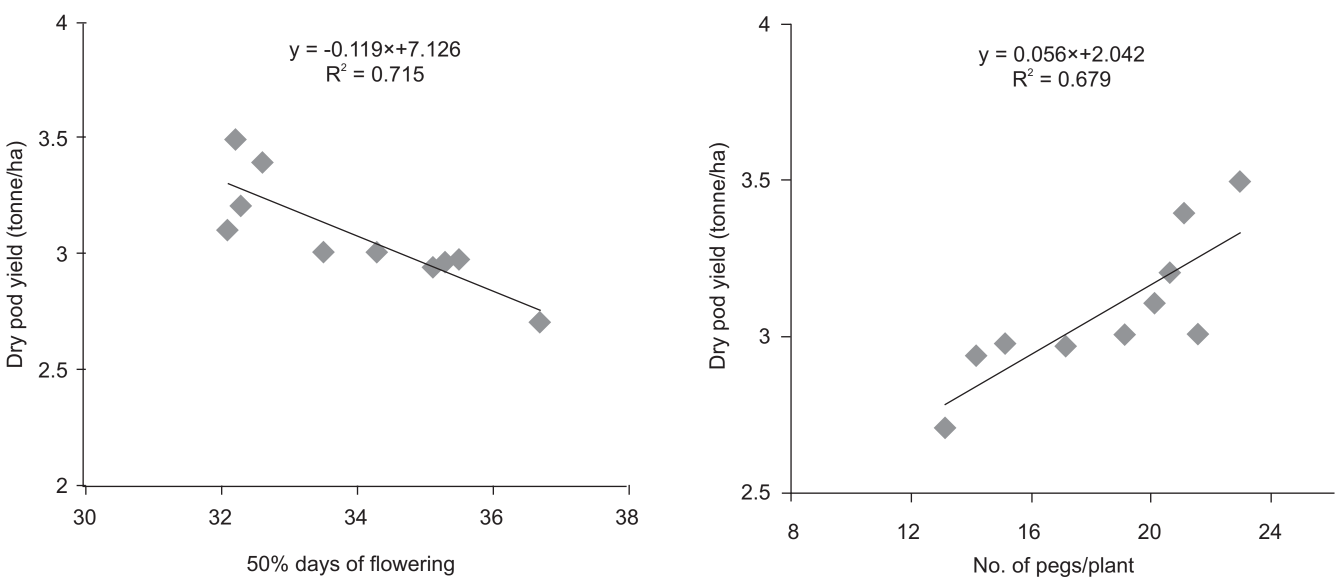

Fig 3 Relationship between 50% days of floweing and total pegs/plant with dry pod yield of groundnut (mean of two years data)

in 50% days of flowering, the dry pod yield of groundnut in different boron applied plots increased (Fig 3). Pods/plant was directly related with the dry pod yield of groundnut crop (Fig 3).

To conclude, the results from the current study indicated that both soil and foliar applied boron have positive effect on growth and yield attributes as well as pod yield. Thus results of the present investigation clearly demonstrate that solubor as soil application @ 10 kg/ha can be applied to achieve better land utilization, high yield as well as productivity and profitability than other treatments under rainfed sandy loam soils.

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